(12) UK Patent Application (19) GB (11) 2 286 038 (13) A

(43) Date of A Publication 02.08.1995

(21) Application No 9500131.9

(22) Date of Filing 05.01.1995

(30) Priority Data
(31) 9400289 (32) 08.01.1994 (33) GB

(71) Applicant(s)
Carver & Co (Engineers) Limited

(Incorporated in the United Kingdom)

Engine Lane, Coppice Side Industrial Estate,
Brownhills, WALSALL, West Midlands, WS8 7ES,
United Kingdom

(72) Inventor(s)
Christopher John Charles Ford
Keith Nigel Bryer
Alan Thomas Wright

(74) Agent and/or Address for Service
H N & W S Skerrett
Charles House, 148/9 Great Charles Street,
BIRMINGHAM, B3 3HT, United Kingdom

(51) INT CL[6]
F23N 5/12

(52) UK CL (Edition N)
F4T THA1 TS6E3 TS6E7 TS7E1J TS7E3 TS7E5D

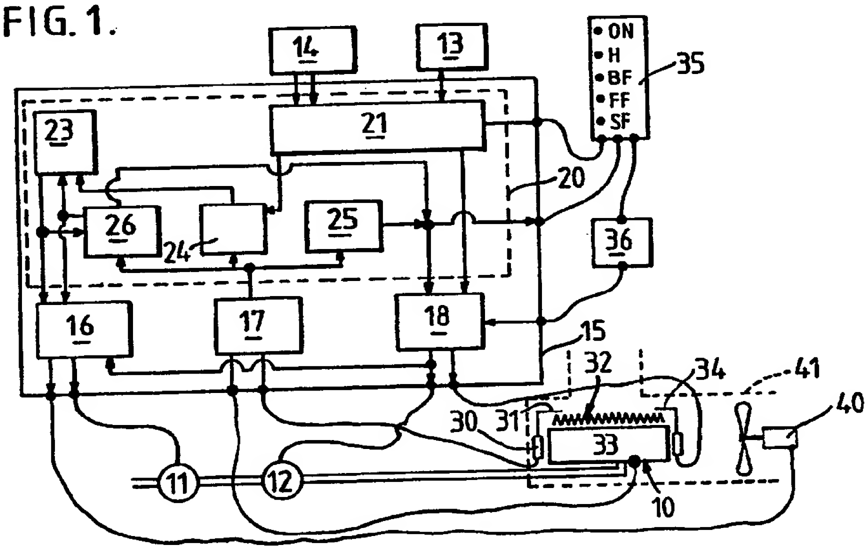
(56) Documents Cited
GB 2270748 A EP 0104586 A1 US 5049063 A

(58) Field of Search
UK CL (Edition N) F4T THA1 THA2 THE1 THG
INT CL[6] F23N 5/08 5/10 5/12
WPI

(54) **Burner control apparatus**

(57) Burner control apparatus comprising a flame failure probe 31, and burner control means 15; wherein the control means is constructed and arranged to measure an electrical effect to which the flame failure probe is exposed so as to obtain from said measurements heat output values representative of an actual heat output from a burner 33, and to compare said heat output values with stored reference information for checking that the burner is operating within predetermined limits, and for actuating a fuel-flow valve 11. The electrical effect measured is either the flame generated voltage to which the probe is subjected or a voltage shift, between an AC voltage applied to the burner and a voltage waveform collected by the probe, caused by ionisation within the flame.

FIG. 1.



GB 2 286 038 A

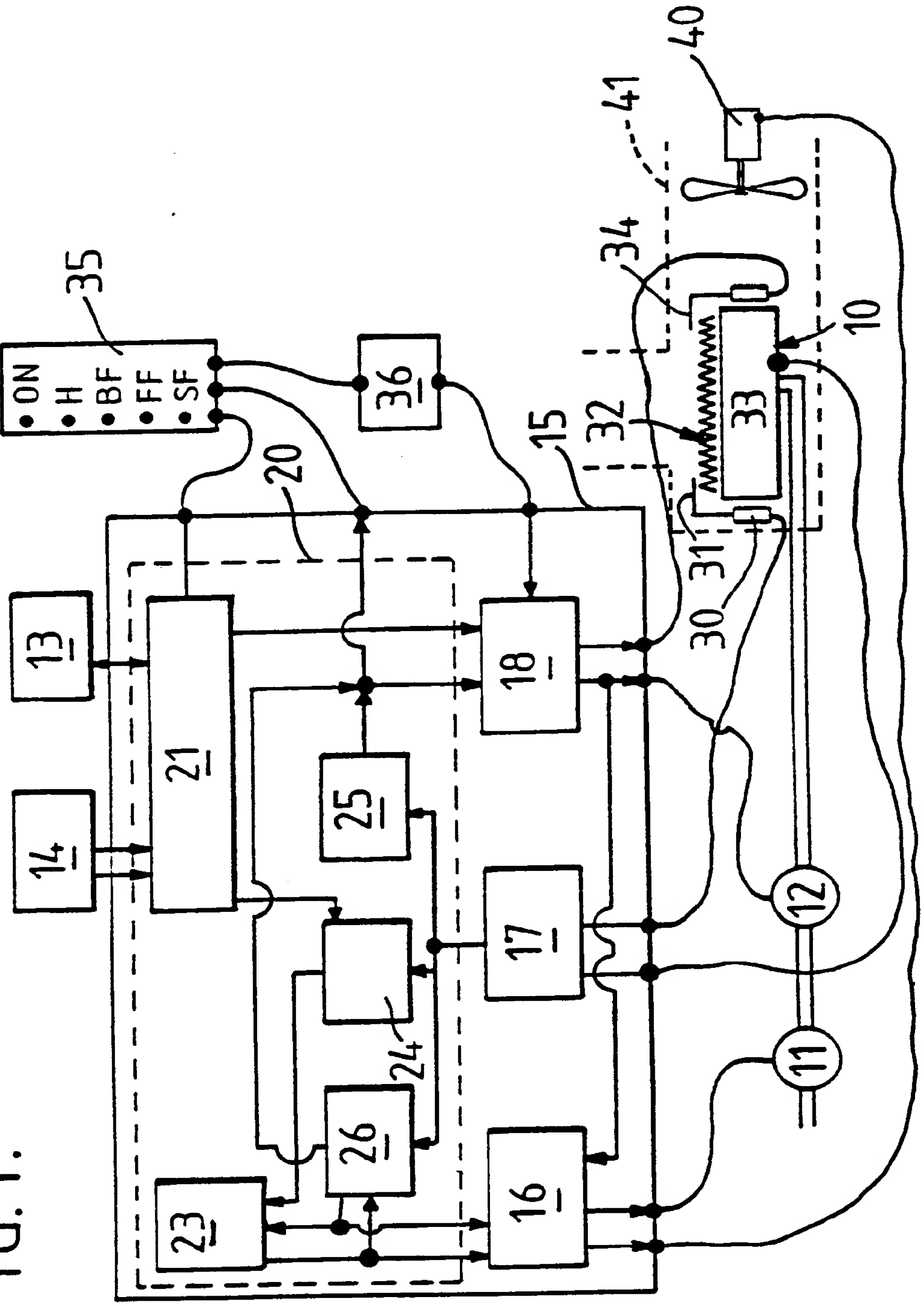

ON
H
BF
FF
SF
35
36
15
20
32
33
34
41
40
10
31
30
13
14
21
25
18
17
24
26
23
16
12
11

FIG. 1.

FIG. 2.

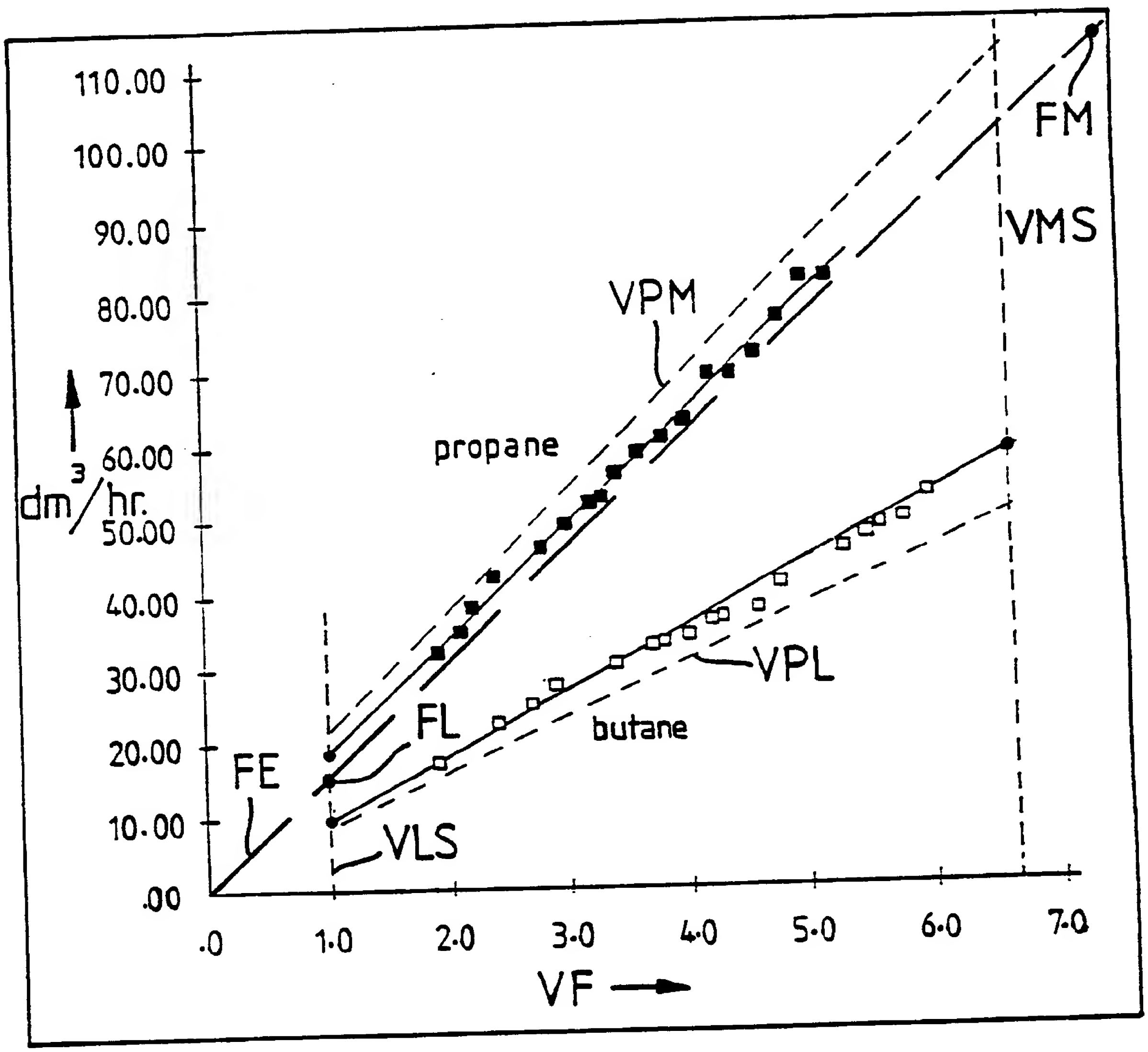
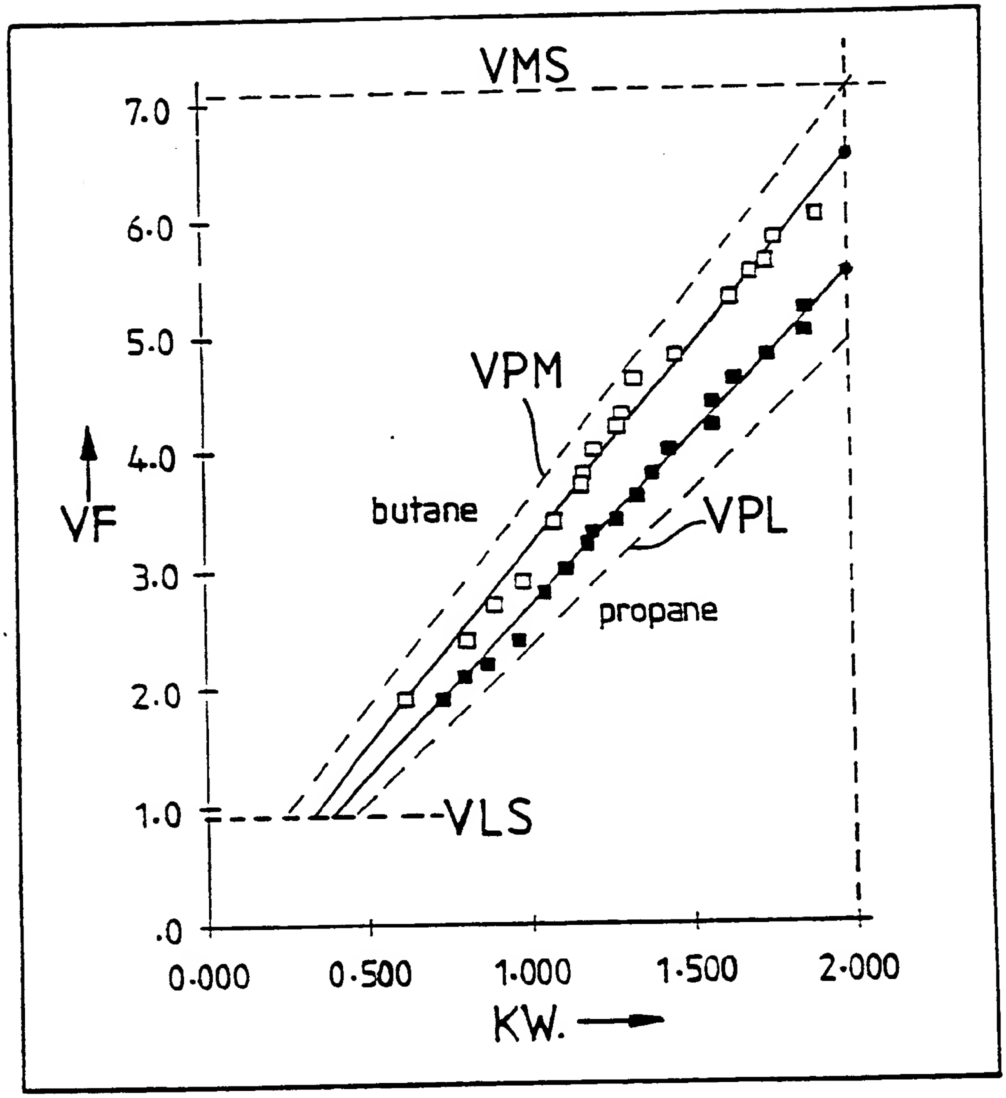

110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
.00
dm³/hr.
.0
1·0
2·0
3·0
4·0
5·0
6·0
7·0
VF
propane
butane
VPM
FM
VMS
FL
FE
VLS
VPL

FIG. 3.


VMS
7.0
6.0
5.0
4.0
3.0
2.0
1.0
.0
VF
VPM
butane
VPL
propane
VLS
0.000
0.500
1.000
1.500
2.000
KW.

BURNER CONTROL APPARATUS

This invention concerns the controlling of gas fuelled burners.

Burner control apparatus usually includes a valve which is controllable, either manually or automatically, to vary the rate of flow of the gas fuel to the burner, for controlling the heat output of the burner. For safety reasons it is known to include a flame failure sensor in the apparatus, to shut off the fuel in the event of the burner being extinguished; and to include an overheat sensor, such as thermostatic cut-out, to shut off the fuel in the event that the burner overheats an appliance, such as a heater, in which the burner is installed.

For automatic control of the valve, it is usual to sense an achieved temperature of whatever is being heated by the burner or the appliance, e.g. a room temperature or a water temperature, and to adjust the valve to reduce the fuel flow rate as or when the achieved temperature nears or reaches a required temperature.

However such apparatus can give rise to various problems including:-

1. Overheating of the medium being heated, resulting in excessive temperatures in said medium existing until such time as the appliance's overheat sensor is

activated. This can, for example, be caused by thermal overshoot, in which the achieved temperature overruns the required temperature e.g. because of control lag or thermal inertia in the overall system.

2. Erratic or otherwise incorrect performance, e.g. because of the gas fuel being supplied at an incorrect rate or pressure which can be caused by non-linear response or incorrect calibration of the gas control valve.

3. Insensitivity of the control apparatus to irregular or deficient combustion of the fuel giving rise to excessive harmful exhaust emissions. This problem can be reduced by incorporation of a flame radiation detector or an exhaust gas analyser and a feedback arrangement into the apparatus, but at a relatively high additional cost and increased bulk and complexity.

More particularly there is known burner control apparatus of a kind comprising a flame failure sensor in the form of an electrically conductive heat resistant probe (which, when located to project into a flame zone of a burner, becomes subject to electrical effects caused by ionisation within the flame). The known flame failure sensor is arranged to utilise the electrical effects of

said ionisation on the probe to determine electrically the presence or absence of a flame.

A proposal in SU 603807A also used such a probe as an electrode for electric current rectification by the flame. The rectified current amplitude is fed, via an amplifier, to a controller which via an indexing mechanism control reversal of a motor to vary the position of a valve controlling the flow along an air or gas line to the burner. Extinction of the flame causes the current to cease and actuate a relay which actuates an emergency valve to shut off the supply of gas to the burner.

In order to enable at least some of said problems to be reduced, the invention primarily provides burner control apparatus comprising a flame failure probe, and burner control means, wherein the control means is constructed and arranged to measure an electrical effect to which the flame failure probe is exposed so as to obtain from said measurements heat output values representative of an actual heat output from a burner, and to compare said heat output values with stored reference information for checking that the burner is operating within predetermined limits, and for actuating a fuel-flow control valve.

There is further provided according to the present invention burner control apparatus comprising a fuel control valve, a flame failure probe, control means to

actuate the valve, a temperature sensor to provide an actual temperature input signal, a setting control to provide a required temperature input signal, and a burner and characterised in that the control means comprises a store holding reference information and is constructed and arranged to:-

(a) determine from actual and required temperature input signals a heat required value representative of a required burner heat output;

(b) measure an electrical effect to which the flame failure probe is exposed, and to derive from said measurements iteratively heat output values representative of the actual heat output from the burner;

(c) to compare said heat output values with the heat required value for controlling said valve to flow fuel at a rate expected to enable the burner to produce said required heat output, and

(d) to compare said heat output values with said reference information for checking that the burner is operating within predetermined limits.

In (c) above, for example, the control means

preferably compares said heat required and output values and utilises any significant difference for adjustment of the actuation of the valve.

The reference information preferably comprises predetermined values determining a performance envelope for safe operation of the burner, and the control means preferably closes the valve if the heat output value moves outside said predetermined values. Such values preferably comprise comparative valve actuation level against heat output value data.

The control means preferably includes a microprocessor in which values are stored as reference data giving correlations between valve actuation data and heat output data for proportional or incremental actuation of the valve, and limit value data for safe operation of the burner. The microprocessor preferably further serves to calculate the heat required value, to effect the comparison for determination of significant difference, and to effect the comparison of the heat output value with the limiting values.

The electrical effect which is measured may be, for example:-

(a) the flame generated voltage to which the probe is subjected;

(b) a voltage shift, between an AC voltage applied to the burner and a voltage waveform collected by the probe, caused by ionisation within the flame, and to facilitate measurement, the waveform collected by the probe is preferably filtered to remove the AC component to leave a DC shift voltage.

The control means preferably comprises an analogue to digital converter to convert the probe or shift voltage directly to a digital measured heat output value. An amplifier having a high input impedance is preferably employed to amplify said voltage prior to conversion.

The valve may be of electrically actuated stepping form to give incremental variation of flow rate, but is preferably an electrically operated modulating valve in which the valve opening is determined by the electrical power applied to the valve to give stepless variation of the flow rate.

The control means preferably performs a comparison of changes of the measured actual output value with changes in the level of actuation of the valve, and provides from the further comparison automatic compensation for at least one non-standard characteristic of the fuel supply, by varying the manner in which the valve is actuated, e.g. to compensate for fuel being supplied at non-standard pressure or for non-standard fuel being supplied.

In embodiments wherein a forced air induction burner is employed, the fan providing the forced air supply may be actuated proportionately with the gas valve to give a substantially constant air fuel ratio. However, the control means is preferably arranged so that where the level of actuation of the valve fails to produce the acceptable measured heat output values, the energisation of the fan is increased above the proportional level until either acceptable measured heat output values are achieved, or some limiting level of fan energisation is reached to actuate a shutting down of the apparatus.

The reference information preferably includes fan actuation limiting values.

The invention further provides heating apparatus incorporating or controlled by the burner control apparatus of the invention.

The invention will be described further, by way of example, with reference to the accompanying diagrammatic drawings, wherein:-

FIGURE 1 shows a schematic circuit with diagrammatic representation of valve and burner components of burner control apparatus of the invention,

FIGURE 2 is a graph showing measured flame voltage against

fuel gas flow, and

FIGURE 3 is a graph showing measured flame voltage against heat output.

The apparatus in this embodiment primarily comprises a burner assembly 10, a modulating valve 11, a safety shut-off valve 12, a temperature sensor 13, a setting device 14 and electrical control means 15. The control means 15 comprises a drive modulator 16, a voltage measuring device 17, an ignitor and safety control device 18 and an electronic system.

The electronic system is organised to perform functions represented notionally as functional blocks in FIGURE 1, any of which blocks or parts thereof may be realised by discrete components or circuits, but the functions of the blocks are in this embodiment performed by a microprocessor 20 indicated in broken lines.

The functional blocks primarily include a heating requirement assessor 21, a valve actuation controller 23, a heating comparator 24, and a safety limit comparator 25; and optionally a performance comparator 26 may be included.

The burner assembly 10 includes a heat resistant probe 30 having a tip 31 which is located in a flame zone 32 of a burner 33, and an ignitor electrode 34 which also

extends into the flame zone. The electrodes 30 and 34 are of similar construction, and either may be omitted if the other is connected to both the device 18 and (via a high voltage protector or cut-out) to the measuring device 17.

The apparatus is arranged to operate on the basis that there is a correlation between the burner's flame ionisation generated or shift voltage V_F derived from the electrical effect picked up by the probe 30 and the the actuation energisation level V of the modulating valve 11. For a given fuel supplied under given pressure the voltage V_F is proportional to the rate of gas flow, as indicated in FIGURE 2 for propane and butane, and is proportional also to the heat output of the burner (FIGURE 3), in which graphs plots (shown as squares) represent experimentally measured flame ionisation or shift voltage V_F and valve energisation V against experimentally directly measured gas flows and heat outputs. Limits can be selected from such experimental data according to selected parameters, such as:-

1. Lower safety limit VLS, for minimum gas flow on the fuel or fuels selected required to ensure that the burner flame is stable and is not vulnerable to becoming unstable or prone to extinguishing; or for minimum heat output.

2. Normal upper limit VMS to limit the maximum heat

output of burner. The limits VMS and VLS are entered into the safety comparator 25.

3. Progressive upper and lower performance limits VPM and VPL to give a safe working performance "envelope" of the acceptable relationships between valve energisation and flame voltage in respect of the selected or each particular fuel for good combustion. The limit data for VPM and VPL against valve energisation is programmed into the performance comparator 26.

The microprocessor is programmed to control the apparatus to effect the following operational functions.

In use, the user operates the setting device 14 to switch on the apparatus, and to set a desired temperature when the appliance is not of a form (such as a water heater) in which the desired temperature is preset.

The need for heating is then assessed (assessor 21) by comparison of the desired temperature with the actual temperature of e.g. the ambient air temperature of the space being heated (or the temperature of the water being heated) detected by the sensing device 13.

If no heating is required, the system enters a standby condition monitoring the need for heating.

If heating is required, the assessor 21 actuates the ignition and safety control device 18 to power the modulator 16 and turn on the valve 12 and to energise the electrode 34; and calculates the rate of heating for fastest temperature rise without overshooting the required temperature and provides an appropriate required rate signal for the heating comparator 24 and the valve actuation controller 23 which provides a modulation signal to the valve drive modulator 16 to energise the modulating valve 11 at the level deemed appropriate or expected to give the required gas flow rate.

As the actual temperature rises, the assessor 21 adjusts the rate signal.

During operation of the burner 33, the ionisation or shift voltage V_F is monitored, i.e. is amplified or filtered and amplified, measured and converted into a digital measured voltage signal, by the device 17, which signal is fed to the comparators.

The measured voltage signals are compared iteratively with the required rate signal by the comparator 24, and any significant difference is input into the controller 23 to incrementally modify the signal to the valve drive modulator 16 to compensate for said difference until the latter falls below a significant level.

The measured voltage signals are compared (by comparator 25) with the limits VLS and VMS and if the signals fall outside said limits for more than a predetermined time (e.g. over more than a predetermined number of checking cycles in an iterative mode of checking), the safety limit comparator 25 causes the device 18 to shut off the valve 12 and to shut off the valve 11 by removing electrical power to the valve drive modulator 16. The burner is thus shut down. If the apparatus has a display unit 35, a burner failure or shut down indication is displayed.

If the apparatus is programmed to effect performance comparison (includes the performance comparator 26), the measured voltage signals are compared with the modulation signal over a number of iterations (period of time) to ascertain if the relationship between valve energisation level and V_F is within the acceptable performance envelope defined by the limits VPM and VPL.

The performance may be outside said performance limits for a number of reasons, for example, the wrong fuel is being supplied, the correct fuel may be being supplied at the wrong pressure, the modulating valve or burner may be defective or the combustion or exhaust air flows to and from the burner may be obstructed.

If the relationship is outside said limits, the

comparator 26 actuates the device 18 to shut down the burner, and causes the display unit 35 to display a failure or the shut down indication.

The control means 15 may be responsive to other inputs, e.g. from safety devices 36, such as thermostats and/or a water level indicator of an appliance in which the burner is installed, for actuating the device 18 to shut down the burner, and optionally to cause the unit 35 to display a system fault indication.

If the apparatus comprises a fan 40 and ductwork 41 for a forced air induction operation of the burner 33, as indicated in broken lines in FIGURE 1, the drive modulator 16 may energise the fan at a level proportional to the level of energisation of the valve 11 so as to maintain a substantially constant air fuel ratio, e.g. it maintains fan energisation on the line FE in FIGURE 2 between FL for minimum air flow at minimum fuel flow and FM for maximum air flow at maximum fuel flow.

However, where a performance comparison is made (by comparator 26) and the comparison indicates that VPL is reached or being approached, the comparator 26 preferably actuates the controller 23 to adjust the drive modulator 16 to raise the level of fan energisation progressively or incrementally above FE until satisfactory burner operation is achieved or the energisation reaches a maximum raised

level on which predetermined information is stored, at which limiting level the comparator 26 actuates the device 18 to shut down the burner. Said maximum raised level may be a maximum proportional increase (such as could be represented by a line offset above FE) or a finite point, e.g. maximum fan energisation.

The ability to increase fan energisation above the proportional level enables the apparatus to function properly in the event of a reduction of fan efficiency or an increase in the resistance to flow of combustion air and burner exhaust such as could be caused by a partial blockage of the flow path thereof.

The unit 35 may also display other indications, e.g. system on and heating.

The invention is not confined to details of the foregoing example, and many variations and modifications are possible within the scope of the invention. For example, comparative reference information concerning the predetermined data for the propane and butane fuels may be stored, and the heating comparator 24, valve controller 23 and performance comparator 26 may be arranged to determine, from said data and the changes in the measured voltages in response to known incremental changes in valve energisation, which fuel is being supplied, and to thereafter control the level of fan and/or valve actuation

to suit the fuel, and/or to provide an indication of the kind of fuel via an appropriate display (not shown) on the display unit 35.

The terms and expressions employed herein are by way of example and are deemed to include equivalents and generic terms and expressions.

The invention further includes and provides apparatus incorporating any novel part or operational feature or combination thereof disclosed herein.

CLAIMS

1. Burner control apparatus comprising a flame failure probe, and burner control means; wherein the control means is constructed and arranged to measure an electrical effect to which the flame failure probe is exposed so as to obtain from said measurements heat output values representative of an actual heat output from a burner, and to compare said heat output values with stored reference information for checking that the burner is operating within predetermined limits, and for actuating a fuel-flow valve.

2. Burner control apparatus comprising a fuel control valve, a flame failure probe, control means to actuate the valve, a temperature sensor to provide an actual temperature input signal, a setting control to provide a required temperature input signal, and a burner and characterised in that the control means comprises a store holding reference information and is constructed and arranged to:-

(a) determine from actual and required temperature input signals a heat required value representative of a required burner heat output;

(b) measure an electrical effect to which the flame failure probe is exposed, and to derive from said measurements iteratively heat output values

representative of the actual heat output from the burner;

(c) to compare said heat output values with the heat required value for controlling said valve to flow fuel at a rate expected to enable the burner to produce said required heat output, and

(d) to compare said heat output values with said reference information for checking that the burner is operating within predetermined limits.

3. Apparatus as claimed in Claim 2 wherein the control means compares said heat required and output values and utilises any significant difference for adjustment of the actuation of the valve.

4. Apparatus as claimed in Claim 2 or 3 wherein the reference information includes predetermined values determining a performance envelope for safe operation of the burner.

5. Apparatus as claimed in Claim 5 wherein said predetermined values comprise comparative values of valve actuation level against heat output values.

6. Apparatus as claimed in Claim 2 or 3 wherein the

control means includes a microprocessor in which values are stored as reference data giving correlations between valve actuation data and heat output data for proportional or incremental actuation of the valve, and limit value data for safe operation of the burner.

7. Apparatus as claimed in Claim 6 wherein the microprocessor further serves to calculate the heat demand value, to effect the comparison for determination of significant difference, and to effect the comparison of the heat output value with the limiting values.

8. Apparatus as claimed in any one of Claims 2 to 7 wherein the control means performs a comparison of changes of the measured actual output value with changes in the level of actuation of the valve, and provides from the further comparison automatic compensation for at least one non-standard characteristic of the fuel supply, by varying the manner in which the valve is actuated.

9. Apparatus as claimed in any one of Claims 2 to 8 and further comprising a fan to provide forced air induction for the burner; wherein the control means actuates the fan proportionately with the valve.

10. Apparatus as claimed in Claim 9 wherein the control means is arranged so that where the level of actuation of the valve fails to produce the acceptable measured heat

output values, the energisation of the fan is increased above the proportional level until either acceptable measured heat output values are achieved, or some limiting level of fan energisation is reached to actuate a shutting down of the apparatus.

11. Apparatus as claimed in any preceding claim wherein the electrical effect which is measured is:-

(a) the flame generated voltage to which the probe is subjected; or

(b) a voltage shift, between an AC voltage applied to the burner and a voltage waveform collected by the probe, caused by ionisation within the flame.

12. Apparatus as claimed in Claim 11 wherein the waveform collected by the probe is filtered to remove the AC component to leave a DC shift voltage.

13. Apparatus as claimed in Claim 11 or 12 wherein the control means comprises an analogue to digital converter to convert the probe or shift voltage directly to a digital measured heat output value.

14. apparatus as claimed in Claim 12 or 13 wherein an amplifier having a high input impedance is employed to amplify said voltage prior to conversion.

15. Apparatus as claimed in any preceding claim wherein the valve is an electrically operated modulating valve in which the valve opening is determined by the electrical power applied to the valve to give stepless variation of the flow rate.

16. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.

17. Heating apparatus incorporating or controlled by the apparatus claimed in any preceding claim.